ROCKETDYNE

ALKALI METAL CORROSION STUDIES

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INTRODUCTION

Rocketdyne has been engaged in research on the use of alkali metals for Rankine power cycles and ion propulsion for several years. In April 1960, the company was awarded a NASA contract to build two columbium loops to study the compatibility of columbium and other refractory metals with potassium under boiling conditions. This report summarizes the company activities on sodium, potassium, cesium, and rubidium corrosion both in loops and capsule tests.

BOILING SODIUM LOOP

A year or so before the NASA contract, Rocketdyne had built a boiling sodium loop as part of company-supported research. The objective was to demonstrate the feasibility of the Rankine cycle including a sodium vapor turbine. The first step was to use a nozzle as a work load in place of the turbine.

The loop employed Haynes Stellite 25, 321 stainless steel, Inconel, and molybdenum for construction materials. After operation at temperatures up to 1860° F, no corrosion was detected.

LOW-TEMPERATURE BOILING POTASSIUM LOOP

When NASA invited Rocketdyne to build and to operate boiling potassium loops for capability studies, the company responded with a proposal to convert the sodium loop to potassium and build two columbium alloy loops to be operated at higher temperatures.

Specimens of molybdenum, columbium - 1% zirconium, columbium, and tantalum were subjected to boiler corrosion at temperatures up to 1800° F with the result that their corrosion resistance varied from that of molybdenum, which was highest, to tantalum in the above order.

CAPSULE CORROSION STUDIES

Supporting potassium compatibility research using capsule experiments has further shown:

(1) When columbium and nickel are present in the same bath of potassium at temperatures above 1450° F, a reaction layer forms on the columbium specimens.

(2) Columbium - 1% zirconium alloy exhibited greater corrosion resistance than columbium when coupled with nickel.

(3) Columbium and columbium - 1% zirconium alloy specimens sealed in columbium - 1% zirconium capsules showed no appreciable weight changes when exposed to potassium at temperatures up to 2000° F. The results for higher temperatures are not yet available.

(4) Intergranular attack was found in columbium weld regions.

HIGH-TEMPERATURE COLUMBIUM BOILING POTASSIUM LOOPS

Two columbium - 1% zirconium loops have been designed to be operated with boiler temperatures of 2000° F and 2200° F. Specimens of tungsten, molybdenum, columbium - 1% zirconium, columbium, and tantalum will be placed at various places in the loop to ascertain their compatibility.

CESIUM AND RUBIDIUM CORROSION STUDIES

The corrosiveness of cesium has been studied in a company-supported program, and its behavior is similar to that of potassium. Intergranular corrosion was detected in nickel samples exposed to cesium at 1830° F.

CONCLUSIONS

Basic studies at Rocketdyne have indicated the following:

(1) Coupling of refractory metals with the transition metal super alloys may lead to transfer.

(2) Intergranular attack may be the principal mechanism for the corrosion of refractory metals by alkali metals.

(3) Oxygen dissolved in alkali metals may prove to affect the rate and mode of corrosion.